

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
12 February 2004 (12.02.2004)

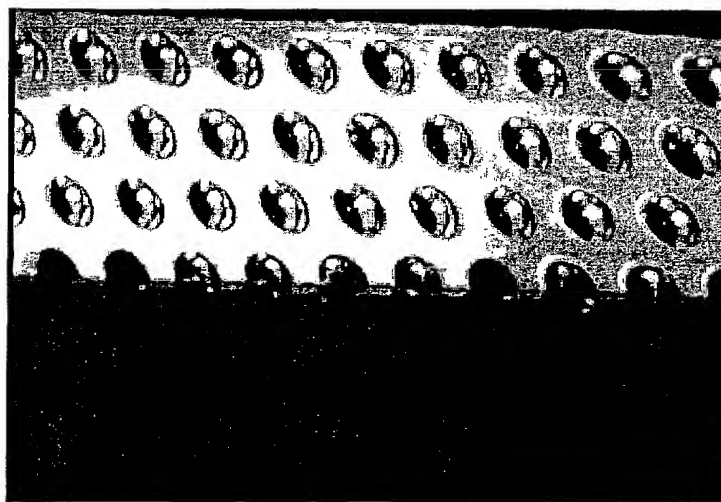
PCT

(10) International Publication Number
WO 2004/012987 A3

- (51) International Patent Classification⁷: **B63B 1/38**
- (21) International Application Number:
PCT/US2003/012950
- (22) International Filing Date: 28 April 2003 (28.04.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
60/375,878 28 April 2002 (28.04.2002) US
Not furnished 28 April 2003 (28.04.2003) US
- (71) Applicant (*for all designated States except US*): **BOARD OF REGENTS** [US/US]; The University of Texas System, 201 W. Seventh Street, Austin, TX 78701 (US).
- (72) Inventor; and
- (75) Inventor/Applicant (*for US only*): **GOLDSTEIN, David, B.** [US/US]; 7700 Chimney Corners Dr., Austin, TX 78731-1525 (US).
- (74) Agent: **NAVARRO, Arthur, I.**; Godwin Gruber, LLP, Renaissance Tower, 1201 Elm St., Suite 1700, Dallas, TX 75270-2084 (US).
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:
— with international search report
- (88) Date of publication of the international search report:
10 June 2004

[Continued on next page]

(54) Title: METHODS FOR REDUCING THE VISCOUS DRAG ON A SURFACE AND DRAG REDUCING DEVICE



Test article showing a large number of flush bubbles held in holes of the type seen in figures 2a, 2b and 2d. The hole diameters are 1/8th inch. The substrate is an aluminum perforated plate backed by a sticky tape. Note that the bubbles remain essentially flush even though the substrate is held roughly vertical. That is, the bubbles do not rise out and are held in place by surface tension. The water is not flowing.

(57) Abstract: A submerged surface is created, either as an add-on application or as an integral part of the submerged structure, having an array of closely spaced small bubble-filled holes which cover a large fraction of the wetted surface area. The viscous drag on the bubbles is much smaller than that on the surrounding solid surface and the net drag on the entire submerged surface is less than that on an equivalent solid surface.



WO 2004/012987 A3



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/12950

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B63B1/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B63B G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 238 434 A (MORAN STEVEN M) 24 August 1993 (1993-08-24)	1, 4, 5
Y	column 6, line 18 - column 7, line 39; figures 4, 6-8	3, 5, 32
Y	EP 0 894 705 A (ISHIKAWAJIMA HARIMA HEAVY IND ;KATO HIROHARU (JP)) 3 February 1999 (1999-02-03) column 7, paragraph 40 - paragraph 41; claim 1; figures 3, 4, 6	32



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *G* document member of the same patent family

Date of the actual completion of the international search

7 January 2004

Date of mailing of the international search report

13/01/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Moya, E

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/12950

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>FONTAINE A A ET AL: "THE INFLUENCE OF THE TYPE OF GAS ON THE REDUCTION OF SKIN FRICTION DRAG BY MICROBUBBLE INJECTION" EXPERIMENTS IN FLUIDS, SPRINGER VERLAG. BERLIN, DT, vol. 13, no. 2 / 3, 1992, pages 128-136, XP000293893 ISSN: 0723-4864 abstract</p> <p style="text-align: center;">---</p>	6,7,30
Y	<p>US 3 213 819 A (GRIFFITH MAY) 26 October 1965 (1965-10-26)</p>	3,5
A	<p>column 3, line 14 -column 5, line 30; figure 3</p> <p style="text-align: center;">---</p>	14-16
A	<p>WO 91 01247 A (VELKE HANS WILLI) 7 February 1991 (1991-02-07) page 4, line 5 -page 5, line 16; figures</p> <p style="text-align: center;">---</p>	1-11
A	<p>US 5 171 623 A (YEE NORMAN D) 15 December 1992 (1992-12-15) column 3, line 66 -column 4, line 20; figures 2-4B</p> <p style="text-align: center;">-----</p>	1-11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 03/12950

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5238434	A	24-08-1993	AU 642809 B2 AU 1103492 A	28-10-1993 01-10-1992
EP 0894705	A	03-02-1999	JP 11049080 A JP 11152077 A BR 9802815 A CA 2242698 A1 CN 1208128 A EP 0894705 A2 FI 981669 A NO 983469 A TW 403815 B US 6092480 A	23-02-1999 08-06-1999 03-11-1999 01-02-1999 17-02-1999 03-02-1999 02-02-1999 02-02-1999 01-09-2000 25-07-2000
US 3213819	A	26-10-1965	NONE	
WO 9101247	A	07-02-1991	AU 6037390 A WO 9101247 A1	22-02-1991 07-02-1991
US 5171623	A	15-12-1992	CA 2082201 A1	06-05-1994